DIGITAL EQUIPMENT CORPORATION

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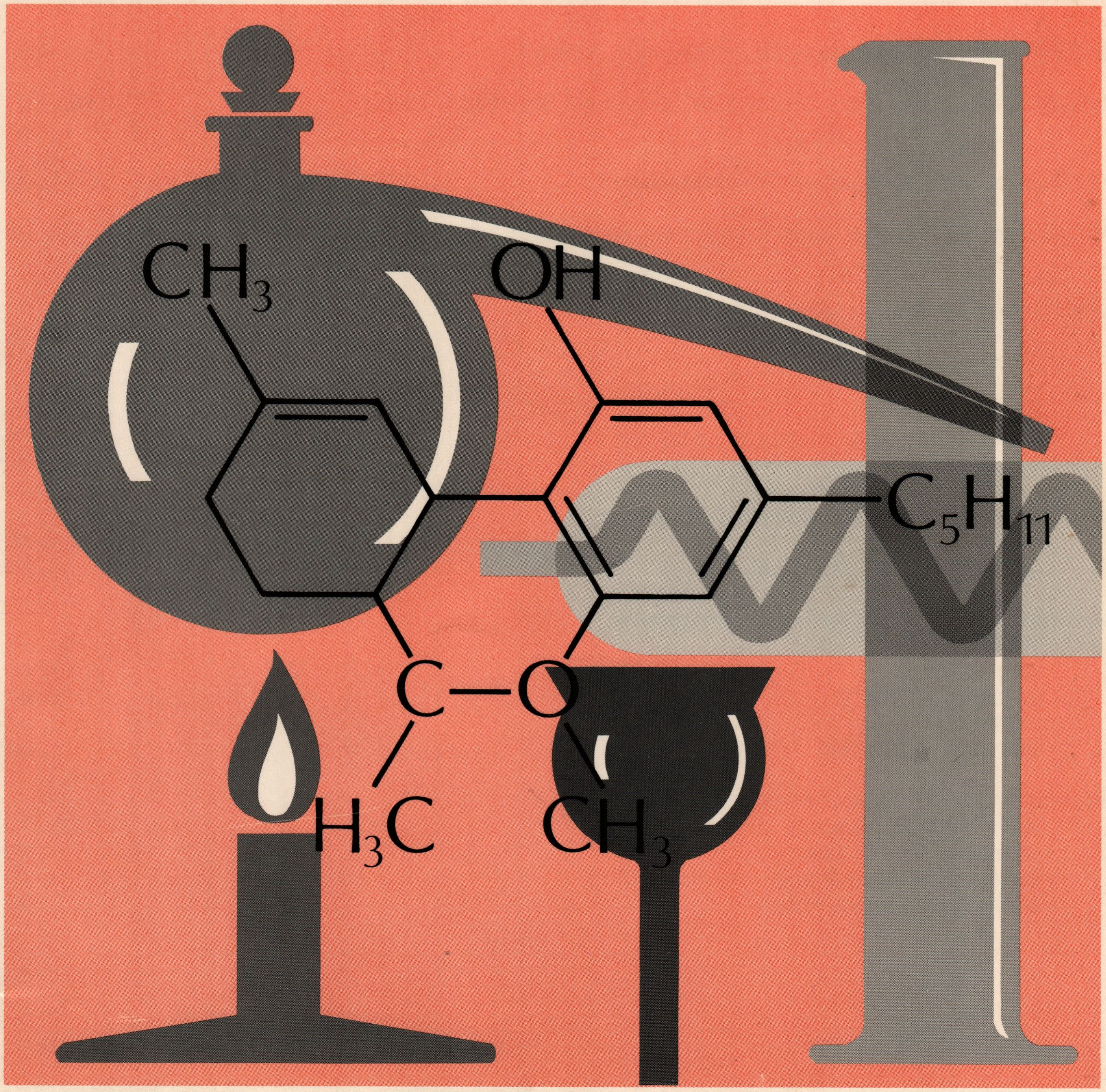
# BASIC Application Programs-Chemistry



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# DIGITAL EQUIPMENT CORPORATION
# EDUCATIONAL PUBLICATIONS

A partial list of the publications in the continuing series of curriculum material published by Digital for use with EduSystems and RSTS is listed below. Please inquire directly for prices on classroom quantities.

Additional publications may be obtained from:

Software Distribution Center
Digital Equipment Corporation
Maynard, Massachusetts 01754

| | |
|---|---|
| Populution: Self Teaching BASIC Workbook | $2.00 |
| BASIC Matrix Operations, Project Solo | $1.00 |
| Computer-Augmented Calculus Topics, Project Solo | $1.50 |
| Problems for Computer Mathematics | $1.25 |
| Advanced Problems for Computer Mathematics | $2.00 |
| BASIC Application Programs | |
| Mathematics I | $1.00 |
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| TEACHER ASSISTANCE | 1.00 |
| Huntington I Simulation Programs | |
| BIOLOGY | $1.00 |
| CHEMISTRY | 2.00 |
| EARTH SCIENCE | 1.00 |
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| SOCIAL STUDIES | 1.00 |
| Huntington II Simulation Modules | |
| Student Workbook | $0.30 |
| Teacher's Guide | .30 |
| Resource Handbook | .50 |
| Program Paper Tape | 1.00 |

# BASIC APPLICATION PROGRAMS

The programs contained in this series are designed to demonstrate how the computer can be applied in a meaningful way to problems of many disciplines. The problems and the corresponding programs are, for the most part, quite simple and are designed to be "jumping off points" for students from the high school level on up.

All of the programs, with very few exceptions, may be run on EduSystems 10 through 80, PDP-8 Family and PDP-11 Family computers. Exceptions are noted in the program descriptions.

Digital Equipment Corporation welcomes contributions of programs and write-ups for use in this series. Contributors will be credited as program "Source". Please send programs and descriptions to Educational Marketing (5-5).

# TABLE OF CONTENTS

| PROGRAM NAME | DESCRIPTION | PAGE |
|---|---|---|
| PRFX | A drill and practice exercise in metric system prefixes. | 1 |
| DIMS | A drill and practice exercise in metric system conversion. | 5 |
| MOLE | A drill routine that provides random problems for practice of gram/mole relationships. | 9 |
| BALC | A tutorial program for balancing chemical equations. | 13 |
| BOYL | A demonstration/practice program based on Boyle's Law. | 17 |
| CHRL | A demonstration/practice program based on Charles' Law. | 21 |
| BOND | A drill and practice program to exercise student knowledge of chemical bonding. | 25 |
| REAC | A laboratory program for analysis of experimental evidence for the law of activity of heat. | 29 |
| KMNO | A laboratory program for volumetric analysis. | 31 |
| PHOH | Demonstrates acid-base relationships expressed on pH and pOH. | 33 |
| QUAL | A laboratory exercise on qualitative analysis for identifying a series of unknowns. | 39 |
| NUCL | A practice program in balancing nuclear equations. | 43 |

# PRFX

## METRIC SYSTEM PREFIXES

**DESCRIPTION:** This drill and practice program is intended to review a student's knowledge of metric system prefixes. Because it is self-administered and self-scoring, PRFX can save valuable class time which would normally require repetitive review of previously learned concepts. It is particularly valuable at the beginning of a chemistry course and may serve as a diagnostic test, as well as a practice exercise.

**PROGRAM LISTING:**

```
 10 REM:  ORIGINAL FOCAL PROGRAM BY JIM STORER---METRIC SYSTEM PREFIXES
 11 PRINT
 15 FORI=1TO14
 16 READA(I)
 17 NEXTI
 18 RESTORE
 19 DATA-1,3,-9,-3,-6,-12,3,4,2,6,2,12,-2,9
 20 PRINT"THIS IS A PROGRAM TO IMPROVE YOUR KNOWLEDGE OF";
 21 PRINT" THE METRIC SYSTEM"
 30 PRINT
 40 PRINT"TERA = 10↑12",,"GIGA = 10↑9"
 50 PRINT"MEGA = 10↑6",,"KILO = 10↑3"
 60 PRINT"HECTO = 10↑2",,"DECA = 10↑1"
 70 PRINT"DECI = 10↑-1",,"CENTI = 10↑-2"
 80 PRINT"MILLI = 10↑-3",,"MICRO = 10↑-6"
 90 PRINT"NANO=MILLIMICRO=10↑-9","PICO=MICROMICRO=10↑-12"
 92 FORQ=1TO4
 94 PRINT
 96 NEXTQ
100 FORB=1TO6
110 PRINT"THE POWER OF 10 FOR THE PREFIX ";
120 ONBGOTO130,140,150,160,170,180
130 PRINT"DECI";
135 GOTO200
140 PRINT"KILO";
145 GOTO200
150 PRINT"NANO";
155 GOTO200
160 PRINT"MILLI";
165 GOTO200
170 PRINT"MICRO";
175 GOTO200
180 PRINT"PICO";
200 PRINT" IS EQUAL TO";
210 INPUTZ
220 IFA(B)=ZTHEN260
230 PRINT"    NO, TRY AGAIN."
240 LETX=X+1
250 GOTO110
260 PRINT"    CORRECT!!"
```

```
 265 PRINT
 270 NEXTB
 300 PRINT
 305 PRINT
 310 PRINT"NOW, LET'S TRY THE REVERSE."
 320 PRINT"(DON'T LOOK AT THE OPENING EXPLANATION!!!!)"
 330 PRINT"CHOOSE YOUR ANSWERS FROM THE FOLLOWING LIST:"
 340 PRINT"MICRO(1)","CENTI(2)","HECTO(3)","TERA(4)","PICO(5)"
 350 PRINT"GIGA(6)","MEGA(7)","QUADRA(8)","NANO(9)","KILO(10)"
 360 PRINT"DECI(11)","OCTA(12)","MILLI(13)","DECA(14)"
 370 PRINT
 380 FORB=7TO10
 385 PRINT
 390 PRINT"WHAT IS THE PREFIX FOR 10↑";
 400 LETC=B+4
 410 PRINTA(C);
 420 INPUTZ
 430 IFZ=A(B)THEN470
 440 PRINT"    NO, TRY AGAIN."
 450 LETX=X+1
 460 GOTO0390
 470 PRINT"    CORRECT!!"
 480 NEXTB
 500 FORQ=1TO4
 505 PRINT
 510 NEXTQ
 520 PRINT"THAT'S ALL."
 525 PRINT"YOU SCORE"X" WRONG!"
 530 PRINT"BYE"
 535 PRINT
1000 END
```

SAMPLE RUN:

```
RUN

THIS IS A PROGRAM TO IMPROVE YOUR KNOWLEDGE OF THE METRIC SYSTEM

TERA = 10↑12                   GIGA = 10↑9
MEGA = 10↑6                    KILO = 10↑3
HECTO = 10↑2                   DECA = 10↑1
DECI = 10↑-1                   CENTI = 10↑-2
MILLI = 10↑-3                  MICRO = 10↑-6
NANO=MILLIMICRO=10↑-9          PICO=MICROMICRO=10↑-12


THE POWER OF 10 FOR THE PREFIX DECI IS EQUAL TO? 1
    NO, TRY AGAIN.
THE POWER OF 10 FOR THE PREFIX DECI IS EQUAL TO? -1
    CORRECT!!

THE POWER OF 10 FOR THE PREFIX KILO IS EQUAL TO? 3
    CORRECT!!

THE POWER OF 10 FOR THE PREFIX NANO IS EQUAL TO? -6
    NO, TRY AGAIN.
THE POWER OF 10 FOR THE PREFIX NANO IS EQUAL TO? -9
    CORRECT!!
```

```
THE POWER OF 10 FOR THE PREFIX MILLI IS EQUAL TO? -3
    CORRECT!!

THE POWER OF 10 FOR THE PREFIX MICRO IS EQUAL TO? -6
    CORRECT!!

THE POWER OF 10 FOR THE PREFIX PICO IS EQUAL TO? -12
    CORRECT!!


NOW, LET'S TRY THE REVERSE.
(DON'T LOOK AT THE OPENING EXPLANATION!!!!)
CHOOSE YOUR ANSWERS FROM THE FOLLOWING LIST:
MICRO(1)      CENTI(2)      HECTO(3)      TERA(4)       PICO(5)
GIGA(6)       MEGA(7)       QUADRA(8)     NANO(9)       KILO(10)
DECI(11)      OCTA(12)      MILLI(13)     DECA(14)

WHAT IS THE PREFIX FOR 10↑ 2 ? 3
    CORRECT!!

WHAT IS THE PREFIX FOR 10↑ 12 ? 4
    CORRECT!!

WHAT IS THE PREFIX FOR 10↑-2 ? 11
    NO, TRY AGAIN.
WHAT IS THE PREFIX FOR 10↑-2 ? 2
    CORRECT!!

WHAT IS THE PREFIX FOR 10↑ 9 ? 6
    CORRECT!!

THAT'S ALL.
YOU SCORE 3  WRONG!
BYE
```

SOURCE: H. Neil Soule, Lexington High School, Lexington, Massachusetts and Project LOCAL, Westwood, Massachusetts

NOTE: The following textbook references will aid in integrating PRFX into classroom lessons.

| | |
|---|---|
| O'Connor[1] | p. 7-8, 18 |
| Metcalfe[2] | p. 11-15, 29 |
| Choppin[3] | p. 696-697 |
| Toon[4] | p. 22-25, 45-46 |
| Slabaough[5] | p. 11-12 |

# DIMS

## METRIC SYSTEM CONVERSIONS

**DESCRIPTION:** This program administers practice to the student in metric system conversions. After a problem is asked, the student has the option of using the built-in mathematics subroutine for aid in making calculations. These subroutines are helpful in eliminating arithmetic errors. DIMS is a self-correcting tutorial program which is valuable as a pre-test or for remedial practice.

**PROGRAM LISTING:**

```
  5 REM:  DIMS
 10 RAN
 20 FORQ=1TO11
 25 READA(Q)
 30 NEXTQ
 35 DATA.01,.001,1E-6,1E-9,10,10,100,1000,1E6,1E9,.1
 40 PRINT"NOTE:  IF YOU WISH TO PERFORM CALCULATIONS FOR THE PROBLEM"
 50 PRINT"  ASKED BY THE COMPUTER, INPUT A ZERO (ZERO) WHEN THE"
 60 PRINT"COMPUTER ASKS FOR AN ANSWER: THIS WILL PUT YOU ON AN ONLINE"
 63 PRINT"MULTIPLY/DIVIDE CALCULATOR.  INPUT A POSITIVE NUMBER IF IT"
 65 PRINT"IS TO BE MULTIPLIED, NEGATIVE IF IT IS TO BE DIVIDED"
 67 PRINT"OR A ZERO IF YOU HAVE FINISHED INPUTTING NUMBERS."
 68 PRINT"FOLLOW EACH INPUTTED NUMBER WITH A CARRIAGE RETURN."
 70 PRINT
 75 PRINT
 80 GOTO200
100 REM:  ON LINE MULTIPLY/DIVIDE SUBROUTINE
105 LETP=1
110 PRINT"INPUT NUMBERS: (+ FOR MULTIPLY, - FOR DIVIDE):"
120 INPUTN
130 ONSGN(N)+2GOTO140,170,150
140 LETP=P/(ABS(N))
145 GOTO120
150 LETP=P*N
160 GOTO120
170 PRINT"  COMPUTED ANSWER="P
180 RETURN
200 LETJ=0
201 PRINT
202 PRINT
203 LETK1=0
205 LETB=RND(I)
210 LETD=INT(RND(I)*9)+1
220 PRINT"CONVERT "D" ";
230 LETH=RND(I)
240 IFB<.5THEN280
250 GOSUB600
260 PRINT"GRAMS";
270 GOTO350
280 IFH<.333THEN310
290 IFH<.667THEN320
300 PRINT"OUNCES";
```

```
305 LETG=454/16
308 GOTO0350
310 PRINT"POUNDS";
315 LETG=454
318 GOTO0350
320 PRINT"TONS";
325 LETG=908000
350 IFJ=0THEN500
360 LETJ=0
370 LETH=0
380 LETD=D/G
390 IFD>10↑9THEN420
400 IFD<10↑-9THEN420
405 PRINT
410 GOTO0800
420 PRINT
423 PRINT"ANS."D" --I CAN'T EVALUATE SUCH A LONG ANSWER"
425 PRINT
430 GOTO0200
500 PRINT" TO ";
510 LETD=D*G
520 LETJ=1
530 LETB=RND(I)
540 GOTO0230
600 LETI=1
610 IFH<I*1/11THEN630
615 LETI=I+1
620 IFI<11THEN610
630 LETG=A(I)
640 ONIGOTO660,670,680,690,700,700,710,720,730,740,650
650 PRINT"DECI";
655 RETURN
660 PRINT"CENTI";
665 RETURN
670 PRINT"MILLI";
675 RETURN
680 PRINT"MICRO";
685 RETURN
690 PRINT"NANO";
695 RETURN
700 PRINT"DECA";
705 RETURN
710 PRINT"HECTO";
715 RETURN
720 PRINT"KILO";
725 RETURN
730 PRINT"MEGA";
735 RETURN
740 PRINT"GIGA";
745 RETURN
800 PRINT"INPUT YOUR ANSWER";
810 INPUTX
820 IFX<>0THEN855
830 GOSUB100
840 PRINT"NOW, INPUT YOUR COMPUTED ANSWER";
850 GOTO0810
855 LETK1=K1+1
860 IFABS(X-D)>.05*DTHEN920
```

```
 870 IFK1=1THEN900
 880 PRINT" GOOD -- RIGHT IN"K1" TRIES"
 890 GOTO975
 900 PRINT" VERY GOOD -- RIGHT IN ONLY ONE TRY!"
 910 GOTO975
 920 IFK1>4THEN950
 930 PRINT" NOT RIGHT -- TRY AGAIN"
 935 PRINT
 940 GOTO800
 950 PRINT" WRONG AGAIN.  THE ANS. IS"D
 960 PRINT" TRY A NEW PROBLEM"
 965 PRINT
 970 GOTO200
 975 PRINT
 980 PRINT"DO YOU WANT ANOTHER PROBLEM: YES(1) OR NO(0)";
 985 INPUTT
 990 IFT=1THEN200
1000 END
```

SAMPLE RUN:

```
RUN
NOTE:  IF YOU WISH TO PERFORM CALCULATIONS FOR THE PROBLEM
ASKED BY THE COMPUTER, INPUT A ZERO (ZERO) WHEN THE
COMPUTER ASKS FOR AN ANSWER: THIS WILL PUT YOU ON AN ONLINE
MULTIPLY/DIVIDE CALCULATOR.  INPUT A POSITIVE NUMBER IF IT
IS TO BE MULTIPLIED, NEGATIVE IF IT IS TO BE DIVIDED
OR A ZERO IF YOU HAVE FINISHED INPUTTING NUMBERS.
FOLLOW EACH INPUTTED NUMBER WITH A CARRIAGE RETURN.




CONVERT  5  MICROGRAMS TO KILOGRAMS
INPUT YOUR ANSWER? 5E-9
 VERY GOOD -- RIGHT IN ONLY ONE TRY

DO YOU WANT ANOTHER PROBLEM: YES(1) OR NO(0)? 1


CONVERT  8  OUNCES TO POUNDS
INPUT YOUR ANSWER? .4
 NOT RIGHT -- TRY AGAIN

INPUT YOUR ANSWER? .5
 GOOD -- RIGHT IN 2  TRIES

DO YOU WANT ANOTHER PROBLEM: YES(1) OR NO(0)? 1


CONVERT  2  HECTOGRAMS TO OUNCES
INPUT YOUR ANSWER? 0
INPUT NUMBERS: (+ FOR MULTIPLY, - FOR DIVIDE):
? 2
? 100
? 16
? -454
? 0
  COMPUTED ANSWER= 7.048458
```

```
NOW, INPUT YOUR COMPUTED ANSWER? 7.0485
 VERY GOOD -- RIGHT IN ONLY ONE TRY!

DO YOU WANT ANOTHER PROBLEM: YES(1) OR NO(0)? 1


CONVERT  8  OUNCES TO POUNDS
INPUT YOUR ANSWER? .5
 VERY GOOD -- RIGHT IN ONLY ONE TRY!

DO YOU WANT ANOTHER PROBLEM: YES(1) OR NO(0)? 0

READY
```

SOURCE: H. Neil Soule, Lexington High School,
Lexington, Massachusetts and Project
LOCAL, Westwood, Massachusetts

NOTE: The following textbook references will aid in integrating DIMS into classroom lessons.

| | |
|---|---|
| O'Connor[1] | p. 7-8, 18 |
| Metcalfe[2] | p. 11-15, 29 |
| Choppin[3] | p. 696-697 |
| Toon[4] | p. 22-25, 45-46 |
| Slabaough[5] | p. 11-12 |

# MOLE

## GRAM/MOLE RELATIONSHIPS

**DESCRIPTION:** The method for conversion of grams to moles and vice-versa is introduced early in a beginning chemistry course. The concept of gram/mole relationships is also used later for more sophisticated problems. MOLE may be used to administer practice to the student several times during the course. The problems are posed at random, so the student encounters a different set of questions in each practice session. The self-scoring feature of this program allows it to be used as a test or quiz as well as a tutorial exercise.

**PROGRAM LISTING:**

```
 10 REM:  MOLE
 20 RAN
 50 FORT=1TO9
 51 READN(T)
 52 NEXTT
 55 DATA18.0,310.3,96.0,189.4,266.7,120.4,44.0,40.0,72.2
100 PRINT
105 PRINT
110 PRINT"DRILL OF GRAM MOLE PROBLEMS"
115 PRINT
117 PRINT
120 PRINT"CONSIDER THE COMPOUND ";
130 LETZ=INT(RND(I)*9)+1
135 LETC=N(Z)
140 ONZGOTO150,160,170,180,190,200,210,220,230
150 PRINT"H2O"
155 GOTO250
160 PRINT"CA3(PO4)2"
165 GOTO250
170 PRINT"(NH4)2CO2"
175 GOTO250
180 PRINT"ZN(NO3)2"
185 GOTO250
190 PRINT"ALBR3"
195 GOTO250
200 PRINT"MGSO4"
205 GOTO250
210 PRINT"CO2"
215 GOTO250
220 PRINT"NAOH"
225 GOTO250
230 PRINT"CAS"
250 LETT=-1*T-1
260 LETZ=INT(99*RND(I))/10
265 PRINT
270 IFT<0THEN290
280 PRINT"TO CONVERT"Z" GRAMS OF THIS SUBSTANCE TO MOLES"
```

```
 285 GOTO300
 290 PRINT"TO CONVERT"Z" MOLES OF THIS SUBSTANCE TO GRAMS"
 300 PRINT"FIRST CALCULATE MOLECULAR WEIGHT (TO 1 DECIMAL PLACE)"
 310 PRINT"MOL. WT. IS";
 320 INPUTA1
 330 IFA1=CTHEN370
 340 PRINT"TRY AGAIN TO GET THE CORRECT ANSWER OF"C
 350 LETW=W+1
 360 GOTO310
 370 PRINT"GOOD!"
 380 PRINT
 390 LETR=R+1
 400 IFT<0THEN440
 410 PRINT"MOLES";
 415 INPUTA1
 420 LETC=Z/C
 430 GOTO470
 440 PRINT"GRAMS";
 450 INPUTA1
 460 LETC=C*Z
 470 IFABS(C-A1)<C/100THEN550
 480 PRINT"TRY AGAIN TO GET THE CORRECT ANSWER OF"INT(C*10000+.5)/10000
 490 LETW=W+1
 500 PRINT"AGAIN";
 510 INPUTA1
 520 GOTO470
 550 PRINT"GOOD!!"
 555 PRINT
 560 LETR=R+1
 570 FORQ=1TO56
 573 PRINT"-";
 574 NEXTQ
 575 PRINT
 580 PRINT"DO YOU WANT ANOTHER PROBLEM: YES(1) OR NO(0)";
 590 INPUTG
 600 IFG=1THEN115
 610 PRINT
 620 PRINT
 630 PRINT"YOU DID"R" PROBLEMS CORRECTLY AND"W" PROBLEMS INCORRECTLY"
 640 PRINT
 650 PRINT
1000 END
```

**SAMPLE RUN:**

```
RUN


DRILL OF GRAM MOLE PROBLEMS


CONSIDER THE COMPOUND ALBR3

TO CONVERT 1.4  MOLES OF THIS SUBSTANCE TO GRAMS
FIRST CALCULATE MOLECULAR WEIGHT (TO 1 DECIMAL PLACE)
MOL. WT. IS? 189.4
TRY AGAIN TO GET THE CORRECT ANSWER OF 266.7
MOL. WT. IS? 266.7
GOOD!
```

```
GRAMS? 356
TRY AGAIN TO GET THE CORRECT ANSWER OF 373.38
AGAIN? 373.38
GOOD!!

---------------------------------------------------------
DO YOU WANT ANOTHER PROBLEM: YES(1) OR NO(0)? 1


CONSIDER THE COMPOUND H20

TO CONVERT 2  GRAMS OF THIS SUBSTANCE TO MOLES
FIRST CALCULATE MOLECULAR WEIGHT (TO 1 DECIMAL PLACE)
MOL. WT. IS? 18
GOOD!

MOLES? .111
GOOD!!

---------------------------------------------------------
DO YOU WANT ANOTHER PROBLEM: YES(1) OR NO(0)? 1

CONSIDER THE COMPOUND CAS

TO CONVERT 1.1  MOLES OF THIS SUBSTANCE TO GRAMS
FIRST CALCULATE MOLECULAR WEIGHT (TO 1 DECIMAL PLACE)
MOL. WT. IS? 44
TRY AGAIN TO GET THE CORRECT ANSWER OF 72.2
MOL. WT. IS? 72.2
GOOD!

GRAMS? 79.42
GOOD!!

---------------------------------------------------------
DO YOU WANT ANOTHER PROBLEM: YES(1) OR NO(0)? 0


YOU DID 6  PROBLEMS CORRECTLY AND 3  PROBLEMS INCORRECTLY



READY
```

SOURCE: H. Neil Soule, Lexington High School,
Lexington, Massachusetts and Project
LOCAL, Westwood, Massachusetts

NOTE: The following textbook references will aid in integrating MOLE into classroom lessons.

| | |
|---|---|
| O'Connor[1] | p. 31-32, 34-36 |
| Metcalfe[2] | p. 55-56, 59, 148-151 |
| Choppin[3] | p. 84-85, 106-107, 112-113 |
| Toon[4] | p. 93-95, 100-102, 116-117 |
| Slabaough[5] | p. 6-7, 12-13, 88-89, 100 |

# BALC

## BALANCING CHEMICAL EQUATIONS

**DESCRIPTION:** BALC is a program which tests the student's ability to balance simple chemical equations. The program asks the student to balance each of twelve chemical equations by filling in the missing coefficient. The program tells the student if his answer is right or wrong; if it is wrong, it gives him the same problem again until he answers it correctly. The program prints the number wrong at the end of the run.

**PROGRAM LISTING:**

```
 10 REM:     BALC
100 PRINTTAB(14);"DRILL FOR BALANCING EQUATIONS"
110 PRINT"CONTAINS A COMPOUND THAT HAS A DOUBLE QUESTION MARK (??)"
120 PRINT"PRECEDING IT.  WHEN YOU ARE ASKED FOR AN ANSWER,"
130 PRINT"SUPPLY A WHOLE NUMBER COEFFICIENT FOR THE QUESTION MARKS"
140 PRINT"WHICH WILL CORRECTLY BALANCE THE EQUATION"
142 FORQ=1TO4
144 PRINT
146 NEXTQ
200 FORI=1TO12
210 READA(I)
220 NEXTI
230 DATA2,3,2,1,2,2,7,3,6,11,3,5
300 FORI=1TO12
310 ONIGOTO500,510,520,530,540,550,560,570,580,590,600,610
320 PRINT"    COEFFICIENT IS";
330 INPUTZ
340 IFZ=A(I)THEN380
350 PRINT"    WRONG, TRY AGAIN."
360 LETX=X+1
370 GOTO310
380 PRINT"    CORRECT!"
382 PRINT
384 PRINT
390 NEXTI
400 FORQ=1TO4
410 PRINT
420 NEXTQ
430 PRINT"THAT'S ALL."
440 PRINT"YOUR SCORE:"X" WRONG!"
450 PRINT"BYE"
460 PRINT
470 PRINT
480 STOP
500 PRINT"H2 + O2 ===> ?? H2O"
505 GOTO320
510 PRINT" ?? H2 + N2 ===> NH3"
515 GOTO320
520 PRINT"H2 + CL2 ===> ?? HCL"
525 GOTO320
```

```
 530 PRINT" ?? CAO + H2O ===> CA(OH)2"
 535 GOTO320
 540 PRINT"BACL2 + NA2(SO4) ===> ?? NACL + BASO4"
 545 GOTO320
 550 PRINT"CU + CL2 ===> ?? CUCL"
 555 GOTO320
 560 PRINT"NH3 + ?? O2 ===> H2O + NO2"
 565 GOTO320
 570 PRINT"FECL3 + ?? NA2CO3 ===> NACL + FE2(CO3)3"
 574 GOTO320
 580 PRINT"FE2O3 + ?? CO ===> FE + CO2"
 585 GOTO320
 590 PRINT"FES2 + ?? O2 ===> FE2O3 + SO2"
 595 GOTO320
 600 PRINT" ?? CAO + P2O5 ===> CA3(PO4)2"
 605 GOTO320
 610 PRINT"NH3 + ?? O2 ===> NO + H2O"
 615 GOTO320
1000 END
```

**SAMPLE RUN:**

```
RUN
                  DRILL FOR BALANCING EQUATIONS
CONTAINS A COMPOUND THAT HAS A DOUBLE QUESTION MARK (??)
PRECEDING IT.  WHEN YOU ARE ASKED FOR AN ANSWER,
SUPPLY A WHOLE NUMBER COEFFICIENT FOR THE QUESTION MARKS
WHICH WILL CORRECTLY BALANCE THE EQUATION




H2 + O2 ===> ?? H2O
    COEFFICIENT IS? 2
    CORRECT!


 ?? H2 + N2 ===> NH3
    COEFFICIENT IS? 3
    CORRECT!


H2 + CL2 ===> ?? HCL
    COEFFICIENT IS? 3
    WRONG, TRY AGAIN.
H2 + CL2 ===> ?? HCL
    COEFFICIENT IS? 2
    CORRECT!


 ?? CAO + H2O ===> CA(OH)2
    COEFFICIENT IS? 2
    WRONG, TRY AGAIN.
 ?? CAO + H2O ===> CA(OH)2
    COEFFICIENT IS? 1
    CORRECT!
```

```
BACL2 + NA2(SO4) ===> ?? NACL + BASO4
    COEFFICIENT IS? 2
    CORRECT!


CU + CL2 ===> ?? CUCL
    COEFFICIENT IS? 2
    CORRECT!


NH3 + ?? O2 ===> H2O + NO2
    COEFFICIENT IS? 7
    CORRECT!

FECL3 + ?? NA2CO3 ===> NACL + FE2(CO3)3
    COEFFICIENT IS? 3
    CORRECT!


FE2O3 + ?? CO ===> FE + CO2
    COEFFICIENT IS? 5
    WRONG, TRY AGAIN.
FE2O3 + ?? CO ===> FE + CO2
    COEFFICIENT IS? 6
    CORRECT!


FES2 + ?? O2 ===> FE2O3 + SO2
    COEFFICIENT IS? 11
    CORRECT!


 ?? CAO + P2O5 ===> CA3(PO4)2
    COEFFICIENT IS? 3
    CORRECT!


NH3 + ?? O2 ===> NO + H2O
    COEFFICIENT IS? 5
    CORRECT!

THAT'S ALL.
YOUR SCORE: 3  WRONG!
BYE


READY
```

**SOURCE:** H. Neil Soule, Lexington High School,
Lexington, Massachusetts and Project
LOCAL, Westwood, Massachusetts

| | |
|---|---|
| PROGRAM MODIFICATION: | The program can be expanded to include more problems. This can be done by adding the appropriate questions in print statements from line 620 to 990, adding the correct answer to the data list in statement 230, adding line references to the new print statements in the ON-GOTO statement in line 312, and changing the index I in lines 200 and 300 to the total number of problems. |
| NOTE: | The following textbook references will aid in integrating BALC into classroom lessons. |

| | |
|---|---|
| O'Connor[1] | p. 44-50, 51-54 |
| Metcalfe[2] | p. 140-142, 152-153 |
| Choppin[3] | p. 100-103, 112 |
| Toon[4] | p. 103-110, 116-117 |
| Slabaough[5] | p. 9-10, 13 |

# BOYL

## BOYLE'S LAW

**DESCRIPTION:** The study of the behavior of gases under ideal conditions is approached through the use of the gas laws. This program aids students in estimating solutions to gas law problems using Boyle's Law. Although designed as a practice exercise, BOYL also can be used to introduce these concepts through classroom demonstration.

**PROGRAM LISTING:**

```
 10 REM:  BOYL
 20 RAN
 90 PRINT
100 PRINTTAB(20);"BOYLES LAW"
110 LETC=0
120 PRINT"INPUT YOUR VALUES FOR V,V1,P,P1 IN THAT ORDER"
130 PRINT"FOR UNKNOWN VALUES USE 0 (ZERO)."
140 PRINT"V";
145 INPUTV
150 PRINT"V1";
155 INPUTV1
160 PRINT"P";
165 INPUTP
170 PRINT"P1";
175 INPUTP1
178 PRINT
180 IFV=0THEN240
185 IFV<0THEN320
190 IFV1=0THEN260
195 IFV1<0THEN320
200 IFP=0THEN280
205 IFP<0THEN320
210 IFP1=0THEN300
220 IFP1<0THEN320
230 PRINT"NO VARIABLES?"
235 GOTO120
240 LETV=P1*V1/P
245 PRINT"ORIGINAL VOLUME ="V
250 GOTO350
260 LETV1=P*V/P1
265 PRINT"NEW VOLUME ="V1
270 GOTO350
280 LETP=P1*V1/V
285 PRINT"ORIGINAL PRESSURE ="P
290 GOTO350
300 LETP1=P*V/V1
305 PRINT"NEW PRESSURE ="P1
310 GOT350
320 PRINT"NO NEGATIVES!!"
330 GOTO120
```

```
 350 PRINT
 355 LETV=INT(RND(I)*50+50)*100
 360 LETV1=INT(RND(I)*50+50)*100
 370 LETP=INT(RND(I)*150+150)
 380 LETP1=INT(RND(I)*150+150)
 385 LETC=C+1
 390 IFC>=5THEN1000
 400 ONCGOTO410,430,450,470
 410 LETV=0
 420 GOTO500
 430 LETV1=0
 440 GOTO540
 450 LETP=0
 460 GOTO540
 470 LETP1=0
 480 GOTO540
 500 PRINT
 505 PRINT"VALUES FOR VOLUMES ARE IN MILLILITRES"
 510 PRINT
 515 PRINT"VALUES FOR PRESSURES ARE IN CM OF MERCURY"
 520 PRINT
 525 PRINT
 530 PRINT"TRY THESE VALUES FOR V,V1,P,P1:"
 540 PRINT"V:"V,"V1:"V1,"P:"P,"P1:"P1
 550 PRINT"WHAT IS YOUR APPROXIMATE ANSWER USING BOYLES LAW";
 560 INPUTQ
 570 PRINT"THE CORRECT ANSWER IS ----"
 580 GOTO180
1000 END
```

SAMPLE RUN:

```
RUN
                       BOYLES LAW
INPUT YOUR VALUES FOR V,V1,P,P1 IN THAT ORDER
FOR UNKNOWN VALUES USE 0 (ZERO).
V? -10
V1? 100
P? 200
P1? 400

NO NEGATIVES!!
INPUT YOUR VALUES FOR V,V1,P,P1 IN THAT ORDER
FOR UNKNOWN VALUES USE 0 (ZERO).
V?
STOP

READY
```

```
RUN

                           BOYLES LAW
 INPUT YOUR VALUES FOR V,V1,P,P1 IN THAT ORDER
 FOR UNKNOWN VALUES USE 0 (ZERO).
V? 0
V1? 100
P? 100
P1? 300

ORIGINAL VOLUME = 300


VALUES FOR VOLUMES ARE IN MILLILITRES

VALUES FOR PRESSURES ARE IN CM OF MERCURY


TRY THESE VALUES FOR V,V1,P,P1:
V: 0           V1: 6400       P: 259         P1: 196
WHAT IS YOUR APPROXIMATE ANSWER USING BOYLES LAW? 4800
THE CORRECT ANSWER IS ----
ORIGINAL VOLUME = 4843.243

V: 6500        V1: 0          P: 222         P1: 224
WHAT IS YOUR APPROXIMATE ANSWER USING BOYLES LAW? 6450
THE CORRECT ANSWER IS ----
NEW VOLUME = 6441.964

V: 7500        V1: 5200       P: 0           P1: 195
WHAT IS YOUR APPROXIMATE ANSWER USING BOYLES LAW? 140
THE CORRECT ANSWER IS ----
ORIGINAL PRESSURE = 135.2

V: 5900        V1: 9500       P: 186         P1: 0
WHAT IS YOUR APPROXIMATE ANSWER USING BOYLES LAW? 120
THE CORRECT ANSWER IS ----
NEW PRESSURE = 115.5158


READY
```

PV = PV

**SUGGESTED ACTIVITY:** Have students investigate PV relationships in the laboratory, using the computer to analyze the data collected.

**SOURCE:** H. Neil Soule, Lexington High School, Lexington, Massachusetts and Project LOCAL, Westwood, Massachusetts

**NOTE:** The following textbook references will aid in integrating BOYL into classroom lessons.

| | |
|---|---|
| O'Connor[1] | p. 55-58, 66-67 |
| Metcalfe[2] | p. 161-165, 172-173 |
| Choppin[3] | p. 53-57, 65-66 |
| Toon[4] | p. 126-130, 157-158 |
| Slabaough[5] | p. 106-109, 123-124 |

# CHRL

## CHARLES' LAW

**DESCRIPTION:** This program provides drill and practice for students in approximating the relationships between volume and temperature using Charles' Law. This approach to understanding the behavior of gases under ideal conditions allows the student to pay close attention to the principles, by mininizing the role that arithmetic plays in the solution. CHRL is also valuable as a class demonstration program in conjunction with discussion.

**PROGRAM LISTING:**

```
 10 REM:     CHRL
 20 RAN
 90 PRINT
100 PRINTTAB(20);"CHARLES LAW"
110 LETC=0
120 PRINT"INPUT YOUR VALUES FOR V,V1,T,T1 IN THAT ORDER"
125 PRINT"TEMPERATURES MUST BE IN KELVIN!"
130 PRINT"FOR UNKNOWN VALUES USE 0 (ZERO)."
140 PRINT"V";
145 INPUTV
150 PRINT"V1";
155 INPUTV1
160 PRINT"T";
165 INPUTT
170 PRINT"T1";
175 INPUTT1
178 PRINT
180 IFV=0THEN240
185 IFV<0THEN320
190 IFV1=0THEN260
195 IFV1<0THEN320
200 IFT=0THEN280
205 IFT<0THEN320
210 IFT1=0THEN300
220 IFT1<0THEN320
230 PRINT"NO VARIABLES?"
235 GOTO120
240 LETV=V1*T/T1
245 PRINT"ORIGINAL VOLUME ="V
250 GOTO350
260 LETV1=V*T1/T
265 PRINT"NEW VOLUME ="V1
270 GOTO350
280 LETT=V*T1/V1
285 PRINT"ORIGINAL TEMPERATURE ="T
290 GOTO350
300 LETT1=T*V1/V
305 PRINT"NEW TEMPERATURE ="T1
310 GOT350
320 PRINT"NO NEGATIVES!!"
```

```
 330 GOTO120
 350 PRINT
 355 LETV=INT(RND(I)*50+50)*100
 360 LETV1=INT(RND(I)*50+50)*100
 370 LETT=INT(RND(I)*125+125)
 380 LETT1=INT(RND(I)*125+125)
 385 LETC=C+1
 390 IFC>=5THEN1000
 400 ONCGOTO410,430,450,470
 410 LETV=0
 420 GOTO500
 430 LETV1=0
 440 GOTO540
 450 LETT=0
 460 GOTO540
 470 LETT1=0
 480 GOTO540
 500 PRINT
 505 PRINT"VALUES FOR VOLUMES APE IN MILLILITRES"
 510 PRINT
 515 PRINT"VALUES FOR TEMPERATURES ARE IN KELVIN"
 520 PRINT
 525 PRINT
 530 PRINT"TRY THESE VALUES FOR V,V1,T,T1:"
 540 PRINT"V:"V,"V1:"V1,"T:"T,"T1:"T1
 550 PRINT"WHAT IS YOUR APPROXIMATE ANSWER USING CHARLES LAW";
 560 INPUTQ
 570 PRINT"THE CORRECT ANSWER IS ----"
 580 GOTO180
1000 END
```

SAMPLE RUN:

```
RUN

                     CHARLES LAW
INPUT YOUR VALUES FOR V,V1,T,T1 IN THAT ORDER
TEMPERATURES MUST BE IN KELVIN!
FOR UNKNOWN VALUES USE 0 (ZERO).
V? 100
V1? 0
T? 100
T1? 300

NEW VOLUME = 300


VALUES FOR VOLUMES ARE IN MILLILITRES

VALUES FOR TEMPERATURES ARE IN KELVIN
```

```
TRY THESE VALUES FOR V,V1,T,T1:
V: 0            V1: 5400       T: 234         T1: 220
WHAT IS YOUR APPROXIMATE ANSWER USING CHARLES LAW? 5240
THE CORRECT ANSWER IS ----
ORIGINAL VOLUME = 5743.636

V: 8200         V1: 0          T: 198         T1: 225
WHAT IS YOUR APPROXIMATE ANSWER USING CHARLES LAW? 9000
THE CORRECT ANSWER IS ----
NEW VOLUME = 9318.182

V: 8300         V1: 7700       T: 0           T1: 152
WHAT IS YOUR APPROXIMATE ANSWER USING CHARLES LAW? 180
THE CORRECT ANSWER IS ----
ORIGINAL TEMPERATURE = 163.8442

V: 9700         V1: 5800       T: 218         T1: 0
WHAT IS YOUR APPROXIMATE ANSWER USING CHARLES LAW? 160
THE CORRECT ANSWER IS ----
NEW TEMPERATURE = 130.3505


READY
```

$V = \frac{kT}{P}$ $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$PV = kT$

**SUGGESTED ACTIVITY:** Have students investigate TV relationships in the laboratory, using the computer to analyze the data collected.

**SOURCE:** H. Neil Soule, Lexington High School, Lexington, Massachusetts and Project LOCAL, Westwood, Massachusetts

**NOTE:** The following textbook references will aid in integrating CHRL into classroom lessons.

| | |
|---|---|
| O'Connor[1] | p. 55-58, 66-67 |
| Metcalfe[2] | p. 161-165, 172-173 |
| Choppin[3] | p. 53-57, 65-66 |
| Toon[4] | p. 126-130, 157-158 |
| Slabaough[5] | p. 106-109, 123-124 |

# BOND

## CHEMICAL BONDING

**DESCRIPTION:** BOND is a program for testing the student's understanding of chemical bonding. The program prints out the name of a compound, its melting temperature, and its boiling temperature, and asks the student to input the types of intermolecular and intramolecular bonds that exist in the compound, based on the data given. The program informs the student this answer is correct or incorrect; in the latter case, BOND gives the same problem until the student gets the correct answer.

**PROGRAM LISTING:**

```
 10 REM:     BOND
 90 PRINT
100 PRINT" THIS PROGRAM WILL GIVE THE NAME, MELTING POINT AND BOILING"
110 PRINT"POINT OF A COMPOUND.  YOU DECIDE WHETHER THE BONDS WITHIN"
120 PRINT"MOLECULES ARE:"
130 PRINT
135 PRINT"        1. METALLIC      2. IONIC      3. COVALENT      4. NONE"
140 PRINT
150 PRINT"AND WHETHER THE BONDS BETWEEN MOLECULES ARE:"
155 PRINT
160 PRINT"  1. METALLIC                   5. HYDROGEN BONDING"
170 PRINT"  2. ELECTROSTATIC ATTRACTION   6. NUMBERS 3 AND 5"
180 PRINT"  3. VAN DER WAALS FORCES       7. NUMBERS 4 AND 5"
190 PRINT"  4. DIPOLE ATTRACTION          8. COVALENT"
200 PRINT
205 PRINT"TYPE THE NUMBER OF THE KIND OF BONDING YOU THINK THE"
210 PRINT"COMPOUND WOULD HAVE BASED ON MELTING AND BOILING TEMPS."
212 PRINT
214 PRINT
216 PRINT
220 FORQ=1TO8
225 READA(Q),B(Q)
227 NEXTQ
229 DATA2,2,3,3,3,3,3,8,3,7,3,3,3,8,3,3
240 PRINT"SUBSTANCE                 MELTING TEMP(K)     BOILING TEMP(K)"
250 PRINT
300 FORI=1TO8
310 ONIGOTO500,510,520,530,540,550,560,570
320 PRINT"INTRAMOLECULAR";
325 INPUTX
330 PRINT"INTERMOLECULAR";
335 INPUTY
340 IFX=A(I)THEN360
350 PRINT"INCORRECT.  TRY AGAIN."
355 GOTO320
360 IFY=B(I)THEN380
370 GOTO350
380 PRINT"CORRECT!!"
383 PRINT
385 PRINT
```

```
 390 NEXTI
 400 PRINT
 410 PRINT"                    ***** DONE *****"
 420 STOP
 500 PRINT"SODIUM CHLORIDE                107.34               1686"
 505 GOTO320
 510 PRINT"CARBON TETRACHLORIDE            250                349.8"
 515 GOTO320
 520 PRINT"CARBON DIOXIDE                 ----           SUBLIMES AT 194.5"
 525 GOTO320
 530 PRINT"SILICON DIOXIDE           ABOUT 2000            ABOUT 2500"
 535 GOTO320
 540 PRINT"WATER                           273                 373"
 545 GOTO320
 550 PRINT"METHANE                          89                 111"
 555 GOTO320
 560 PRINT"DIAMOND                   ABOVE 3800            ABOUT 4500"
 565 GOTO320
 570 PRINT"XYLENE                          247                  47"
 575 GOTO320
1000 END
```

SAMPLE RUN:

```
RUN

 THIS PROGRAM WILL GIVE THE NAME, MELTING POINT AND BOILING
POINT OF A COMPOUND.  YOU DECIDE WHETHER THE BONDS WITHIN
MOLECULES ARE:

      1. METALLIC     2. IONIC     3. COVALENT     4. NONE

AND WHETHER THE BONDS BETWEEN MOLECULES ARE:

  1. METALLIC                  5. HYDROGEN BONDING
  2. ELECTROSTATIC ATTRACTION  6. NUMBERS 3 AND 5
  3. VAN DER WAALS FORCES      7. NUMBERS 4 AND 5
  4. DIPOLE ATTRACTION         8. COVALENT

TYPE THE NUMBER OF THE KIND OF BONDING YOU THINK THE
COMPOUND WOULD HAVE BASED ON MELTING AND BOILING TEMPS.
```

```
SUBSTANCE                  MELTING TEMP(K)      BOILING TEMP(K)

SODIUM CHLORIDE               107.34                  1686
INTRAMOLECULAR? 2
INTERMOLECULAR? 2
CORRECT!!


CARBON TETRACHLORIDE           250                    349.8
INTRAMOLECULAR? 3
INTERMOLECULAR? 3
CORRECT!!


CARBON DIOXIDE                 ----             SUBLIMES AT 194.5
INTRAMOLECULAR? 3
INTERMOLECULAR? 4
INCORRECT.  TRY AGAIN.
INTRAMOLECULAR? 3
INTERMOLECULAR? 3
CORRECT!!


SILICON DIOXIDE             ABOUT 2000             ABOUT 2500
INTRAMOLECULAR? 3
INTERMOLECULAR? 8
CORRECT!!


WATER                          273                     373
INTRAMOLECULAR? 3
INTERMOLECULAR? 7
CORRECT!!


METHANE                         89                     111
INTRAMOLECULAR? 3
INTERMOLECULAR? 3
CORRECT!!


DIAMOND                     ABOVE 3800             ABOUT 4500
INTRAMOLECULAR? 3
INTERMOLECULAR? 8
CORRECT!!


XYLENE                         247                      47
INTRAMOLECULAR? 4
INTERMOLECULAR? 3
INCORRECT.  TRY AGAIN.
INTRAMOLECULAR? 3
INTERMOLECULAR? 3
CORRECT!!



                ***** DONE *****

READY
```

**SOURCE:** H. Neil Soule, Lexington High School, Lexington, Massachusetts and Project LOCAL, Westwood, Massachusetts

**PROGRAM MODIFICATION:** The program can be expanded to include more questions. This can be done by adding the appropriate questions in the print statements in lines 580 to 990, adding the correct answers to the end of the data list in line 229, changing the indexes I and Q in lines 220 300 to the total number of questions, and adding the appropriate line references to the new PRINT statements in the ON-GOTO statement in line 310.

**NOTE:** The following textbook references will aid in integrating BOND into classroom lessons.

| | |
|---|---|
| O'Connor[1] | p. 168-188, 329-350 |
| Metcalfe[2] | p. 91-108, 110-112, 116 |
| Choppin[3] | p. 460-461, 469-470 |
| Toon[4] | p. 281-282, 315-318, 289-291, 299-301 |
| Slabaough[5] | p. 51-63, 73-78 |

# REAC

## HEAT OF A CHEMICAL REACTION

**DESCRIPTION:** The student can gain deeper understanding of the principles involving the heat of a chemical reaction by writing a program similar to this one. The concept of heat measurement involves basic calorimetry; once the student understands the mathematics involved, he can attempt to write a program to process laboratory results.

**PROGRAM LISTING:**

```
 10 REM:     REAC
 20 REM:     SAMPLE PROGRAM FOR HEAT OF A CHEMICAL REACTION
100 PRINT"PROGRAMMED BY JOHN DOE"
110 PRINT"LAB #26 -- REACTION HEAT"
120 PRINT
130 FORX=1TO3
140 PRINT"REACTION"X
150 PRINT"======== ="
160 PRINT
170 PRINT"MASS H2O";
180 INPUTM(X)
190 PRINT"STARTING TEMP.";
200 INPUTR(X)
210 PRINT"HIGHEST TEMP.";
220 INPUTS(X)
230 PRINT"BEAKER MASS";
240 INPUTH
250 LETQ(X)=S(X)-R(X)
260 LETZ=M(X)*Q(X)+H*Q(X)*.2
270 PRINT
280 PRINT"ENERGY =="Z
290 PRINT"EN./M NAOH =="Z*.02
295 PRINT
300 NEXTX
310 PRINT"%ERROR =="((Q(1)+Q(3))-Q(2))/Q(2)*.01
320 PRINT
330 PRINT"GOOD BYE"
340 PRINT
400 END
```

SAMPLE RUN:

```
RUN
PROGRAMMED BY JOHN DOE
LAB #26 -- REACTION HEAT

REACTION 1
======== =

MASS H20? 100
STARTING TEMP.? 0
HIGHEST TEMP.? 8
BEAKER MASS? 45

ENERGY == 872
EN./M NAOH == 17.44

REACTION 2
======== =

MASS H20? 175
STARTING TEMP.? 15
HIGHEST TEMP.? 27
BEAKER MASS? 41

ENERGY == 2198.4
EN./M NAOH == 43.968

REACTION 3
======== =

MASS H20? 200
STARTING TEMP.? 70
HIGHEST TEMP.? 102
BEAKER MASS? 40

ENERGY == 6656
EN./M NAOH == 133.12

%ERROR == .02333333
```

SOURCE: H. Neil Soule, Lexington High School, Lexington, Massachusetts and Project LOCAL, Westwood, Massachusetts

SUGGESTED ACTIVITIES: Have students construct their own calorimeters using different materials and calculate their calorimeter constant. Write a computer program which will allow anyone to supply data and get proper values for a calorimeter.

NOTE: The following textbook references will aid in integrating REAC into classroom lessons.

| | |
|---|---|
| O'Connor[1] | p. 192-202, (exp. 26 lab manual) |
| Metcalfe[2] | p. 395-396, 415-416 |
| Choppin[3] | p. 309-314, 316-317 |
| Toon[4] | p. 369-375, 390-391 |
| Slabaough[5] | p. 257-258, 270-271 |

## STANDARDIZATION OF POTASSIUM PERMANGANATE SOLUTION

DESCRIPTION: This program was designed as a student-written exercise to aid in determining laboratory results of an experiment which standarizes a potassium permanganate solution. Potassium permanganate is often used as an indicator in chemical solutions where oxidation-reduction is occuring. The permanganate ion's concentration is usually standardized by measuring it against a primary agent or compound as a primary step in the determination. KMNO uses the computer to aid in calculations that must be made once the titration data has been collected. The student must be familiar with the idea of moles, molarity, and the titration process before he will be able to write a program similar to this one.

PROGRAM LISTING:

```
 10 REM:     KMNO
100 PRINT
110 PRINT"WHAT IS THE STARTING MEASUREMENTS OF THE KMNO 4 SOL.";
120 INPUTA
130 PRINT"WHAT IS THE FINAL MEASUREMENT OF THE KMNO 4 SOL.";
140 INPUTB
150 LETC=ABS(A-B)
160 PRINT"HOW MANY GRAMS OF NA2C204 DID YOU USE";
170 INPUTD
180 LETE=D/124
190 LETG=158*2*E/5
200 LETR=1000/C
210 LETG=G*R
215 PRINT
218 PRINT"GRAMS PER LITRE:"G
220 PRINT" THE MOLAR STRENGTH OF THE SOLUTION IS:"G/158
230 PRINT
240 PRINT"DO YOU HAVE ANOTHER PROBLEM: YES(1) OR NO(0)";
250 INPUTQ
260 PRINT
270 IFQ=1THEN110
280 END
```

SAMPLE RUN:

```
RUN

WHAT IS THE STARTING MEASUREMENTS OF THE KMNO 4 SOL.? 2.1
WHAT IS THE FINAL MEASUREMENT OF THE KMNO 4 SOL.? 11.1
HOW MANY GRAMS OF NA2C204 DID YOU USE? .27

GRAMS PER LITRE: 15.29032
 THE MOLAR STRENGTH OF THE SOLUTION IS: .09677419

DO YOU HAVE ANOTHER PROBLEM: YES(1) OR NO(0)? 1

WHAT IS THE STARTING MEASUREMENTS OF THE KMNO 4 SOL.? 12.9
WHAT IS THE FINAL MEASUREMENT OF THE KMNO 4 SOL.? 19.4
HOW MANY GRAMS OF NA2C204 DID YOU USE? .22

GRAMS PER LITRE: 17.25062
 THE MOLAR STRENGTH OF THE SOLUTION IS: .1091811

DO YOU HAVE ANOTHER PROBLEM: YES(1) OR NO(0)? 0


READY
```

SOURCE: H. Neil Soule, Lexington High School
Lexington, Massachusetts and Project
LOCAL, Westwood, Massachusetts

NOTE: The following textbook references will aid in integrating KMNO into classroom lessons.

| | |
|---|---|
| O'Connor[1] | p. 86-87, 100-101 |
| Metcalfe[2] | p. 289-290, 300-301 |
| Choppin[3] | p. 348-349 |
| Toon[4] | p. 493-495, 498-499 |
| Slabaough[5] | p. 97-99, 102 |

# PHOH

## ACID-BASE RELATIONSHIPS EXPRESSED AS pH and pOH

DESCRIPTION: PHOH is a program which presents the basic learning materials for understanding pH and pOH. The material is first presented in three units, and then the student is tested on what he has just learned. The three units are; conversion from H+ ion concentrations to pH; conversion from pH to H+ ion concentrations; test incorporating pOH, pH, H+ ion concentration, and determining whether the solution is acidic, basic, or neutral. The program first asks pH to H+ ion concentrations (and the reverse) questions and tells the student if the answer is correct or incorrect. If the response is incorrect, PHOH returns the correct answer. The program then gives the OH- concentration and asks for the pOH, pH, the H+ ion concentration, and whether the solution is acid, base, or neutral. The program asks five questions for each unit, and stops automatically after the last question. The numerical data for questions are random, so that a student can rerun the program without worry of repetition.

PROGRAM LISTING:

```
  1 REM*  PHOH
  5 RAN
 10 GOTO100
 40 FORX=1TO5
 45 LETH(X)=INT(RND(I)*14)+1
 46 IFX<2THEN55
 47 FORM=1TOX-1
 48 IFH(X)=H(M)THEN45
 49 NEXTM
 55 ONAGOTO200,305,420
 60 NEXTX
 62 PRINT
 63 PRINT
 65 RETURN
100 PRINT
110 PRINT"THE DEFINITION OF PH IS -LOG[H+]."
120 PRINT"BUT THIS CAN BE THOUGHT OF AS 'P' STANDING FOR 'POWER',"
130 PRINT"SO PH= THE NEGATIVE EXPONENT OF THE H+ ION CONCENTRATION."
135 PRINT"FOR EXAMPLE, IF [H+] =10 ↑ 6, THE PH= -(-6) OR +6."
140 PRINT
150 LETA=1
155 GOSUB40
160 LETA=2
163 PRINT"NOW LET'S TRY THE REVERSE:"
164 PRINT
165 GOSUB40
170 LETA=3
172 PRINT"POH CAN BE DETERMINED FROM THE OH- ION CONCENTRATION"
174 PRINT"AND POH + PH = 14 SINCE KW=[H+]*[OH-] = 10↑-14."
175 PRINT
```

```
 177 GOSUB40
 178 PRINT
 180 PRINT"THAT'S ALL"
 182 PRINT
 184 PRINT
 186 PRINT"BYE"
 190 STOP
 200 PRINT"IF THE H+ CONCENTRATION IS 1*10↑"-H(X)" WHAT IS THE PH";
 210 INPUTP
 220 IFP=H(X)THEN260
 230 GOSUB900
 240 PRINTH(X)
 245 PRINT
 250 GOTO60
 260 PRINT"CORRECT!"
 270 PRINT
 280 GOTO60
 305 PRINT"IF THE PH IS"H(X)" -THE H+ ION CONCENTRATION IS";
 306 PRINT" 1 X 10 TO WHAT";
 310 INPUTP
 320 IFP=-H(X)THEN260
 330 GOSUB900
 340 PRINT" 1*1P↑"-H(X)
 345 PRINT
 350 GOTO60
 420 PRINT"IF THE OH- CONCENTRATION IS 1*10↑"-H(X)" -WHAT IS POH";
 430 INPUTP
 435 LETC=14-H(X)
 440 IFP=H(X)THEN470
 450 GOSUB900
 455 PRINTH(X)
 456 PRINT
 460 GOTO480
 470 PRINT"CORRECT!"
 475 PRINT
 480 PRINT"WHAT IS THE PH";
 490 INPUTP
 500 IFP=CTHEN530
 510 GOSUB900
 520 PRINTC
 523 PRINT
 525 GOTO540
 530 PRINT"CORRECT!"
 535 PRINT
 540 PRINT"THE H+ CONCENTRATION IS 1 X 10 TO WHAT";
 550 INPUTP
 560 IFP=-CTHEN590
 5W0 GOSUB900
 580 PRINT"1*10↑"-C
 585 GOTO595
 590 PRINT"CORRECT!"
 595 PRINT
 600 PRINT"IS THE SOLUTION ACID(1), NEUTRAL(2), OR BASIC(3)";
 610 INPUTP
 620 LETL=SGN(C-7)+2
 630 IFP=LTHEN260
 640 PRINT"NO, TRY AGAIN."
 650 GOTO600
 900 PRINT"NO, THE ANSWER SHOULD BE:";
 910 RETURN
1000 END
```

SAMPLE RUN:

```
RUN

THE DEFINITION OF PH IS -LOG[H+].
BUT THIS CAN BE THOUGHT OF AS 'P' STANDING FOR 'POWER',
SO PH= THE NEGATIVE EXPONENT OF THE H+ ION CONCENTRATION.
FOR EXAMPLE, IF [H+] =10 ↑ 6, THE PH= -(-6) OR +6.

IF THE H+ CONCENTRATION IS 1*10↑-10  WHAT IS THE PH? -10
NO, THE ANSWER SHOULD BE: 10

IF THE H+ CONCENTRATION IS 1*10↑-8  WHAT IS THE PH? 8
CORRECT!

IF THE H+ CONCENTRATION IS 1*10↑-2  WHAT IS THE PH? 2
CORRECT!

IF THE H+ CONCENTRATION IS 1*10↑-14  WHAT IS THE PH? 14
CORRECT!

IF THE H+ CONCENTRATION IS 1*10↑-1  WHAT IS THE PH? 2
NO, THE ANSWER SHOULD BE: 1



NOW LET'S TRY THE REVERSE:

IF THE PH IS 6  -THE H+ ION CONCENTRATION IS 1 X 10 TO WHAT? 6
NO, THE ANSWER SHOULD BE: 1*10↑-6

IF THE PH IS 4  -THE H+ ION CONCENTRATION IS 1 X 10 TO WHAT? -4
CORRECT!

IF THE PH IS 13  -THE H+ ION CONCENTRATION IS 1 X 10 TO WHAT? -13
CORRECT!

IF THE PH IS 1  -THE H+ ION CONCENTRATION IS 1 X 10 TO WHAT? 11
NO, THE ANSWER SHOULD BE: 1*10↑-1

IF THE PH IS 3  -THE H+ ION CONCENTRATION IS 1 X 10 TO WHAT? -3
CORRECT!



POH CAN BE DETERMINED FROM THE OH- ION CONCENTRATION
AND POH + PH = 14 SINCE KW=[H+]*[OH-] = 10↑-14.

IF THE OH- CONCENTRATION IS 1*10↑-1  -WHAT IS POH? 1
CORRECT!

WHAT IS THE PH? 13
CORRECT!

THE H+ CONCENTRATION IS 1 X 10 TO WHAT? -13
CORRECT!

IS THE SOLUTION ACID(1), NEUTRAL(2), OR BASIC(3)? 3
CORRECT!
```

```
IF THE OH- CONCENTRATION IS 1*10↑-5  -WHAT IS POH? -5
NO, THE ANSWER SHOULD BE: 5

WHAT IS THE PH? 9
CORRECT!

THE H+ CONCENTRATION IS 1 X 10 TO WHAT? -9
CORRECT!

IS THE SOLUTION ACID(1), NEUTRAL(2), OR BASIC(3)? 1
NO, TRY AGAIN.
IS THE SOLUTION ACID(1), NEUTRAL(2), OR BASIC(3)? 3
CORRECT!

IF THE OH- CONCENTRATION IS 1*10↑-6  -WHAT IS POH? 6
CORRECT!

WHAT IS THE PH? 9
NO, THE ANSWER SHOULD BE: 8

THE H+ CONCENTRATION IS 1 X 10 TO WHAT? -8
CORRECT!

IS THE SOLUTION ACID(1), NEUTRAL(2), OR BASIC(3)? 3
CORRECT!

IF THE OH- CONCENTRATION IS 1*10↑-10  -WHAT IS POH? 10
CORRECT!

WHAT IS THE PH? 4
CORRECT!

THE H+ CONCENTRATION IS 1 X 10 TO WHAT? -5
NO, THE ANSWER SHOULD BE:1*10↑-4

IS THE SOLUTION ACID(1), NEUTRAL(2), OR BASIC(3)? 1
CORRECT!

IF THE OH- CONCENTRATION IS 1*10↑-3  -WHAT IS POH? 3
CORRECT!

WHAT IS THE PH? 11
CORRECT!

THE H+ CONCENTRATION IS 1 X 10 TO WHAT? -11
CORRECT!

IS THE SOLUTION ACID(1), NEUTRAL(2), OR BASIC(3)? 2
NO, TRY AGAIN.
IS THE SOLUTION ACID(1), NEUTRAL(2), OR BASIC(3)? 3
CORRECT!



THAT'S ALL

BYE
```

**SOURCE:** H. Neil Soule, Lexington High Schoool, Lexington, Massachusetts and Project LOCAL, Westwood, Massachusetts

**SUGGESTED ACTIVITIES:** Assign students to the task of writing a computer program that will find the pH of various solutions they have used in a titration experiment in the laboratory.

**NOTE:** The following textbook references will aid in integrating PHOH into classroom lessons.

| | |
|---|---|
| O'Connor[1] | p. 263-264, 276 |
| Metcalfe[2] | p. 281-283, 300-301 |
| Choppin[3] | p. 380-382, 387 |
| Toon[4] | p. 478-482, 496-498 |
| Slabaough[5] | p. 217-219, 231 |

# QUAL

## QUALITATIVE ANAYSIS

**DESCRIPTION:** Most elementary chemistry courses contain laboratory exercises involving introductory qualitative analysis. Once the student understands the scheme of analysis by working in the laboratory, he can write a program like QUAL to aid him in identifying various unknowns.

**PROGRAM LISTING:**

```
 10 REM:  QUAL
 40 DATA1,3,3,1,3,4,1,3,1,1,3,5,3,3,3,3,2,3,1,1,1,1,3,6
 50 DATA1,3,3,1,2,4,1,3,1,1,2,5,1,1,1,1,2,6,1,3,1,1,3,7
 60 DATA1,1,1,1,3,8,1,1,1,1,3,9,3,3,3,3,3,3
 90 PRINT
100 PRINTTAB(17);"QUALITATIVE ANALYSIS"
110 PRINT"THIS PROGRAM WILL DETERMINE THE IDENTITY OF AN UNKNOWN"
120 PRINT"CATION OR MIXTURE OF TWO CATIONS OF THE GROUP TWO METALS"
130 PRINT"GIVEN THE LAB DATA.  DATA SHOULD BE TYPED IN ACCORDING"
140 PRINT"TO THE FOLLOWING KEY."
150 PRINT"TYPE '1' IF PPT IS HEAVY"
160 PRI"TYPE '2' IF PPT IS LIGHT OR SLIGHT"
170 PRINT"TYPE '3' IF NO PPT"
180 PRINT"TYPE '4' IF FLAME TEST SHOWS ORANGE"
190 PRINT"TYPE '5' IF FLAME TEST SHOWS RED"
200 PRINT"TYPE '6' IF FLAME TEST SHOWS GREEN"
210 PRINT"TYPE '7' IF FLAME TEST SHOWS FIRST ORANGE, THEN RED"
220 PRINT"TYPE '8' IF FLAME TEST SHOWS FIRST ORANGE, THEN GREEN"
230 PRINT"TYPE '9' IF FLAME TEST SHOWS FIRST GREEN, THEN RED"
235 PRINT
240 PRINT
250 PRINT"CARBONATE RESULT IS";
255 INPUTA
258 PRINT
260 PRINT"CHROMATE RESULT IS";
265 INPUTB
268 PRINT
270 PRINT"OXALATE RESULT IS";
275 INPUTC
278 PRINT
280 PRINT"SULFATE RESULT IS";
285 INPUTD
288 PRINT
290 PRINT"HYDROXIDE RESULT IS";
295 INPUTE
298 PRINT
300 PRINT"FLAME TEST RESULT IS";
```

```
305 INPUTG
308 PRINT
400 FORZ=1TO11
410 READA1,B1,C1,D1,E1,G1
420 IFA<>A1THEN480
430 IFB<>B1THEN480
440 IFC<>C1THEN480
450 IFD<>D1THEN480
460 IFE<>E1THEN480
470 IFG=G1THEN510
480 NEXTZ
490 PRINT"INCORRECT DATA GIVEN"
500 GOTO950
510 IFZ<5THEN800
515 IFZ=11THEN940
520 GOTO820
800 PRINT"THE UNKNOWN IS THE CATION ";
810 GOTO830
820 PRINT"THE UNKNOWN IS A MIXTURE OF ";
830 ONZGOTO840,850,860,870,880,890,900,910,920,930
840 PRINT"CALCIUM"
845 GOTO950
850 PRINT"STRONTIUM"
855 GOTO950
860 PRINT"MAGNESIUM"
865 GOTO950
870 PRINT"BARIUM"
875 GOTO950
880 PRINT"MAGNESIUM AND CALCIUM"
885 GOTO950
890 PRINT"MAGNESIUM AND STRONTIUM"
895 GOTO950
900 PRINT"MAGNESIUM AND BARIUM"
905 GOTO950
910 PRINT"CALCIUM AND STRONTIUM"
915 GOTO950
920 PRINT"CALCIUM AND BARIUM"
925 GOTO950
930 PRINT"STRONTIUM AND BARIUM"
935 GOTO950
940 PRINT"THE UNKNOWN MUST BE WATER!"
950 PRINT
955 RESTORE
960 PRINT"TRY AGAIN?-- YES(1) OR NO(0)";
970 INPUTQ
980 IFQ=1THEN235
990 PRINT"BYE"
995 PRINT
1000 END
```

**SAMPLE RUN:**

```
RUN

                           QUALITATIVE ANALYSIS
THIS PROGRAM WILL DETERMINE THE IDENTITY OF AN UNKNOWN
CATION OR MIXTURE OF TWO CATIONS OF THE GROUP TWO METALS
GIVEN THE LAB DATA.  DATA SHOULD BE TYPED IN ACCORDING
TO THE FOLLOWING KEY.
TYPE '1' IF PPT IS HEAVY
TYPE '2' IF PPT IS LIGHT OR SLIGHT
TYPE '3' IF NO PPT
TYPE '4' IF FLAME TEST SHOWS ORANGE
TYPE '5' IF FLAME TEST SHOWS RED
TYPE '6' IF FLAME TEST SHOWS GREEN
TYPE '7' IF FLAME TEST SHOWS FIRST ORANGE, THEN RED
TYPE '8' IF FLAME TEST SHOWS FIRST ORANGE, THEN GREEN
TYPE '9' IF FLAME TEST SHOWS FIRST GREEN, THEN RED


CARBONATE RESULT IS? 1

CHROMATE RESULT IS? 3

OXALATE RESULT IS? 3

SULFATE RESULT IS? 1

HYDROXIDE RESULT IS? 3

FLAME TEST RESULT IS? 4

THE UNKNOWN IS THE CATION CALCIUM

TRY AGAIN?-- YES(1) OR NO(0)? 1


CARBONATE RESULT IS? 1

CHROMATE RESULT IS? 1

OXALATE RESULT IS? 1

SULFATE RESULT IS? 1

HYDROXIDE RESULT IS? 2

FLAME TEST RESULT IS? 6

THE UNKNOWN IS A MIXTURE OF MAGNESIUM AND BARIUM

TRY AGAIN?-- YES(1) OR NO(0)? 1
```

```
CHROMATE RESULT IS? 3

OXALATE RESULT IS? 3

SULFATE RESULT IS? 3

HYDROXIDE RESULT IS? 3

FLAME TEST RESULT IS? 3

THE UNKNOWN MUST BE WATER!

TRY AGAIN?-- YES(1) OR NO(0)? 1


CARBONATE RESULT IS? 2

CHROMATE RESULT IS? 2

OXALATE RESULT IS? 2

SULFATE RESULT IS? 2

HYDROXIDE RESULT IS? 3

FLAME TEST RESULT IS? 8

INCORRECT DATA GIVEN

TRY AGAIN?-- YES(1) OR NO(0)? 0
BYE


READY
```

SOURCE: H. Neil Soule, Lexington High School,
Lexington, Massachusetts and Project
LOCAL, Westwood, Massachusetts

NOTE: The following textbook references will aid in integrating QUAL into classroom lessons.

| | |
|---|---|
| O'Connor[1] | (Experiment 19-20, lab manual) |
| Slabaough[5] | p. 358-359, 360 |

# NUCL

## NUCLEAR EQUATIONS

**DESCRIPTION:** This program administers practice in balancing nuclear equations. The fact that nuclei do remain intact during chemical reactions and that much larger energies are required for nuclear charge is often demonstrated in beginning chemistry courses through discussion of nuclear equation. NUCL presents the student with one incomplete nuclear equation at a time and asks for the type of nuclear particle needed to balance the equation.

**PROGRAM LISTING:**

```
  5 REM:  NUCL PROGRAM
 10 FORQ=1TO16
 12 READP(Q)
 14 NEXTQ
 15 DATA7,2,7,4,2,3,6,7,3,4,4,2,5,6,1,2
 18 PRINT
 19 PRINT
 20 PRINT"DRILL--NUCLEAR EQUATIONS"
 30 PRINT"THIS PROGRAM WILL DRILL YOU ON YOUR ABILITY TO SOLVE"
 40 PRINT"NUCLEAR EQUATIONS FOR MISSING RADIOACTIVE PARTICLES."
 50 PRINT"WHEN GIVEN THE PROBLEM, ANSWER IT WITH ONE OF THE"
 60 PRINT"FOLLOWING PARTICLES: PROTON, ALPHA, GAMMA, NEUTRON,"
 70 PRINT"DEUTERON, POSITRON, OR BETA."
 80 PRINT"TO STOP THE PROGRAM TYPE 0 FOR PROBLEM NUMBER"
 90 PRINT"PROBLEM NUMBERS ARE 1 TO 16"
100 PRINT"USE '1' FOR PROTON, '2' FOR ALPHA, '3' FOR GAMMA,"
110 PRINT"    '4' FOR NEUTRON, '5' FOR DEUTERON, '6' FOR POSITRON,"
120 PRINT"    '7' FOR BETA."
150 PRINT
160 PRINT
170 PRINT"PROBLEM NUMBER";
180 INPUTM
185 IFABS(M-8)>8THEN900
188 LETA=P(M)
190 IFM<11THEN210
200 ONM-10GOTO320,330,340,350,360,370
210 ONM+1GOTO1000,220,230,240,250,260,270,280,290,300,310
220 PRINT"NO. 1:  (14)SI(27)---->(13)AL(27) + X"
225 GOTO600
230 PRINT"NO. 2:  (94)PU(239) + X---->(96)CM(243)"
235 GOTO600
240 PRINT"NO. 3:  (92)U(239)---->(93)NP(239) + X"
245 GOTO600
250 PRINT"NO. 4:  (27)CO(59) + X---->(27)CO(60)"
255 GOTO600
260 PRINT"NO. 5:  (88)RA(226)---->(86)RN(222) + X"
265 GOTO600
```

```
 270 PRINT"NO. 6:  (92)U(238)---->(92)U(238) + X"
 275 GOTO600
 280 PRINT"NO. 7:  (82)PB(211)---->(81)TL(211) + X"
 285 GOTO600
 290 PRINT"NO. 8:  (87)FR(223)---->(88)RA(223) + X"
 295 GOTO600
 300 PRINT"NO. 9:  (85)AT(215)---->(85)AT(215) + X"
 305 GOTO600
 310 PRINT"NO. 10:  (92)U(238) + X---->(92)U(239)"
 315 GOTO600
 320 PRINT"NO. 11:  (96)CM(244) + (6)C(13)---->(102)NO(253) + 4(X)"
 325 GOTO600
 330 PRINT"NO. 12:  (13)AL(27) + (1)H(2)---->(12)MG(25) + X"
 335 GOTO600
 340 PRINT"NO. 13:  (11)NA(23) + X---->(11)NA(24) + (1)H(1)"
 345 GOTO600
 350 PRINT"NO. 14:  (1)H(1) + (1)H(1)---->(1)H(2) + X"
 355 GOTO600
 360 PRINT"NO. 15:  2[(2)HE(3)]---->(2)HE(4) + 2(X)"
 365 GOTO600
 370 PRINT"NO. 16:  (1)HE(3) + (1)H(1)---->X"
 375 GOTO600
 600 PRINT"X IS";
 610 INPUTX
 620 IFX=ATHEN650
 630 PRINT"WRONG ANSWER, TRY AGAIN: "
 640 GOTO190
 650 PRINT"CORRECT ANSWER!"
 660 GOTO160
 900 PRINT"NO SUCH PROBLEM NUMBER EXISTS!"
 910 GOTO160
1000 END
```

SAMPLE RUN:

```
RUN


DRILL--NUCLEAR EQUATIONS
THIS PROGRAM WILL DRILL YOU ON YOUR ABILITY TO SOLVE
NUCLEAR EQUATIONS FOR MISSING RADIOACTIVE PARTICLES.
WHEN GIVEN THE PROBLEM, ANSWER IT WITH ONE OF THE
FOLLOWING PARTICLES: PROTON, ALPHA, GAMMA, NEUTRON,
DEUTERON, POSITRON, OR BETA.
TO STOP THE PROGRAM TYPE 0 FOR PROBLEM NUMBER
PROBLEM NUMBERS ARE 1 TO 16
USE '1' FOR PROTON, '2' FOR ALPHA, '3' FOR GAMMA,
    '4' FOR NEUTRON, '5' FOR DEUTERON, '6' FOR POSITRON,
    '7' FOR BETA.
```

```
PROBLEM NUMBER? 1
NO. 1:  (14)SI(27)---->(13)AL(27) + X
X IS? 7
CORRECT ANSWER!

PROBLEM NUMBER? 2
NO. 2:  (94)PU(239) + X---->(96)CM(243)
X IS? 2
CORRECT ANSWER!

PROBLEM NUMBER? 3
NO. 3:  (92)U(239)---->(93)NP(239) + X
X IS? 6
WRONG ANSWER, TRY AGAIN:
NO. 3:  (92)U(239)---->(93)NP(239) + X
X IS? 7
CORRECT ANSWER!

PROBLEM NUMBER? 10
NO. 10:  (92)U(238) + X---->(92)U(239)
X IS? 4
CORRECT ANSWER!

PROBLEM NUMBER? 12
NO. 12:  (13)AL(27) + (1)H(2)---->(12)MG(25) + X
X IS? 2
CORRECT ANSWER!

PROBLEM NUMBER? 15
NO. 15:  2[(2)HE(3)]---->(2)HE(4) + 2(X)
X IS? 6
WRONG ANSWER, TRY AGAIN:
NO. 15:  2[(2)HE(3)]---->(2)HE(4) + 2(X)
X IS? 1
CORRECT ANSWER!

PROBLEM NUMBER? 18
NO SUCH PROBLEM NUMBER EXISTS!

PROBLEM NUMBER? 6
NO. 6:  (92)U(238)---->(92)U(238) + X
X IS? 6
WRONG ANSWER, TRY AGAIN:
NO. 6:  (92)U(238)---->(92)U(238) + X
X IS? 3
CORRECT ANSWER!

PROBLEM NUMBER? 8
NO. 8:  (87)FR(223)---->(88)RA(223) + X
X IS? 7
CORRECT ANSWER!

PROBLEM NUMBER? 9
NO. 9:  (85)AT(215)---->(85)AT(215) + X
X IS? 3
CORRECT ANSWER!

PROBLEM NUMBER? 0

READY
```

SOURCE: H. Neil Soule, Lexington High School, Lexington, Massachusetts and Project LOCAL, Westwood, Massachusetts

PROGRAM MODIFICATION: The program can be expanded by including new questions. This can be accomplished by including the new questions in print statements in lines 380 to 590, including the correct answers at the end of the data list in statement 15, changing the index Q in line 10 to the total number of problems, including the appropriate line references in the ON-GOTO statement in line 200, and by changing the number 8 in statement 185 to equal one-half of the total number of problems.

NOTE: The following textbook references will aid in integrating NUCL into classroom lessons.

| | |
|---|---|
| O'Connor[1] | p. 410-416, 425-426 |
| Metcalfe[2] | p. 616-620, 629 |
| Choppin[3] | p. 670-672, 693 |
| Toon[4] | p. 733-741, 752 |
| Slabaough[5] | p. 364-366, 369-370, 376 |

# REFERENCES

1 O'Connor, Davis, et al., Chemistry: Experiments and Principles, D. C. Heath, Lexington, Massachusetts, 1968.

2 Metcalfe and Williams, Modern Chemistry, Holt, Rinehart, and Winston, New York, 1970.

3 Choppin and Jaffe, Chemistry: Science of Matter, Energy, and Change, Silver Burdett, Morristown, New Jersey, 1965.

4 Toon, Ellis and Brodkin, Foundations of Chemistry, Holt Rinehart and Winston, New York, 1968.

5 Slabaough and Parsons, General Chemistry, Wiley and Sons, New York, 1966.

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